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Review Article

# Mechanisms of Perifocal-M Therapeutic Impact and Long-Term Data in Children with Progressive Myopia

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## Abstract

The article discusses in detail the multifactorial mechanisms of the impact of spectacles with perifocal defocus on progression of myopia in children. Impact on local retinal mechanisms of neuroregulatory control of eye growth currently most effective in preventing the development and progression of myopia. Optical correction of peripheral hyperopia with the formation of peripheral myopic defocus affects the manifestation of a biochemical cascade from the retina to the choroid and to the sclera, which inhibits the eye growth. Optical methods of controlling myopia, including spectacles, are widely used in local and foreign ophthalmic practice. Since 2011 spectacles with Perifocal-M lenses have been used in Russia, providing greater impact functionality on myopic eyes in comparison with foreign counterparts. The design features of such spectacle lenses have a complex effect on various optical and physiological structures of the eye, each of which contributes to refractogenesis. Perifocal spectacles take into account the characteristics of the central and peripheral refraction characteristic of the myopic eye along the horizontal and vertical meridians. They have stronger horizontal refraction, which allows to eliminate the optical imbalance, specific for myopic eye and creates an emmetropic optical profile. Construction of perifocal spectacle lenses allows you to correct relative peripheral hyperopia, to create myopic defocus in the horizontal meridian, affect the ratio of refractive indices of the nasal and temporal halves of the retina. This is due to an earlier onset and more pronounced optical effect on the nasal half of the retina relative to temporal. Spectacles with perifocal defocus induce positive spherical aberration in the eye, increase the accommodative ability of the eye, help maintain high binocular visual acuity, improve binocular interaction during near-work, impede the development of heterophoria. Optical features of Perifocal-M spectacles create conditions for versatile functional effects on various structures of the eye, which leads to deterrence the process of myopia progression.

***Keywords:*** *Perifocal-M; Children; Progressive Myopia*

## Introduction

At last International myopic conference, once again, was noticed, that revealed by Josh Wallman [1] local retinal mechanisms of neuroregulatory management of eye growth in model experiments in animals, at present day proved in human and methods to affect said mechanisms is the most effective to prevent myopia progression [2]. Optical correction of relative peripheral hyperopia with creation of peripheral myopic defocus, provokes biochemical cascade from retina to choroid and to sclera, which holding the eye growth. Treatment of progressive myopia by creation of peripheral myopic defocus, also popular in Russian ophthalmologic practice using both: contact methods and spectacles.

Current possibilities of optical production, in particular, free form technology, lets us to create new designs of optical surfaces with non-axial symmetric shapes, that was beginning of new spectacle lens occurrence, which provides different correction of axial and non-axial refraction to control myopia. At present day there are three lenses of this type in international optometric practice. Since 2011, mainly in South-East Asia, widely used lenses with radial progression called Myovision, one of inventors of this lens was famous Australian scientist Brien Holden. Construction feature of said lens is central aperture of stable refraction with 20mm diameter with additional positive refraction of 1,9D on periphery in 25mm from optical center. Construction is asymmetric for right and left eyes. According study results conducted in 2009, which involved 210 children, it was found, that in treatment group by refraction and axial length data progression of myopia was 30% less comparing to control group [3]. Authors noticed, that the most effect of myopia control by Myovision spectacles was in children of myopic parents.

In September of 2017 at the International myopia conference in plenary section, dedicated to optical methods of myopia control, was presented clinical study results of using Multi segment lenses in children with progressive myopia. Lens created in association with Hong Kong polytechnic university. Construction features are in original way to create fast progression from 10mm central zone border by multiple micro segments with 1,5mm diameter, each of segment has additional refraction of 3,5D.According two-years randomize clinical study results, which involved 160 children, divided to treatment (79 children) and control(81 children) groups, noticed, that children used Multi segment lenses had 59% less progression ($p < 0,0001$) by autorefractor data and 60% less($p < 0,0001$) by axial length comparing to control group used monofocal lenses [4].

Almost at the same time with Myovision lens optometrists start to use Perifocal lens in their practice, it was designed by famous specialist in the field of spectacle lenses design modeling professor Jose Alonso (University Complutense of Madrid). Features of Perifocal lens optical design providing wider functionality for influence on myopic eye comparing to lens said before. Optical construction of Perifocal lens provides stable refraction in geometric center and asymmetric progression of refraction to the both sides in horizontal plane passing through geometric center. Refraction progression for each side has asymmetric start point from geometric center. Refraction along vertical meridian is almost equal to refraction in geometric center. Lens has it's nasal and temporal sides relative to lens position in front of the eye. Addition in nasal side starts from 5,5 mm and in temporal- 3,5 mm from geometric center and reaches its maximum value of 2,5D at nasal side and 3,0D at temporal at 24 mm from geometric center.

Since 2011, many comprehensive studies have shown that the optical design of the lens Perifocal creates conditions for the impact on various etiopathogenetic factors of myopia.

**Perifocal spectacle lenses consider the characteristics of the central and peripheral refraction along the horizontal and vertical meridians in the myopic eye:** The known features of the ellipsoid shape of the myopic eye, in contrast to the spherical shape of the emmetropic eye, create an optical imbalance in it, where along the vertical Meridian there is mainly a relative peripheral myopia and the relative peripheral hyperopia is determined horizontally [5,6]. According to the given justifications of J. Wall man in his famous scientific hypothesis, the myopic eye receives conflicting signals along the vertical and horizontal meridians, the eye will grow along the axis until the myopic Central part of the retina balances the relatively hyperopic periphery, ignoring the relative peripheral myopia along the vertical meridian [7]. Functional – morphological features of the retinal topography also show the importance of the relative peripheral hyperopia correction in the horizontal meridian. Thus, the density of cones and ganglion cells decreases more rapidly to the periphery along the vertical meridian, in contrast to the horizontal, which reflects the potentially dominant effect of visual signals from the retina horizontally relative to the vertical field of view [7,8]. The Perifocal lens has a stronger horizontal refraction, which when correcting the myopic eye allows to eliminate the characteristic optical imbalance and thereby create an emmetropic optical profile in the myopic eye.

**Perifocal spectacles correct relative peripheral hyperopia and create myopic defocus in the horizontal meridian:** Relative peripheral hyperopia characteristic for the myopic eye in the horizontal meridian contributes to the disturbance of local homeostasis [7]. The results of studies show that hyperopic defocus with respect to the retina causes thinning of the vascular and lengthening of the eye-

ball, in turn, myopic defocus causes thickening of the vascular and a decrease in the axial length of the eye [9]. Clinical studies have shown that the design features of the Perifocal lenses correcting relative peripheral hyperopia or create myopic defocus [10] that provides the conditions for influence on local neuro-regulatory mechanisms of eye growth control.

**Perifocal spectacles affects the ratio between nasal and temporal halves refraction:** Off-axis refraction studies in the period of progression of myopia have shown that the ratio of the refraction values of the nasal and temporal parts in most cases asymmetrically, this fact is noted in numerous works, starting with the first descriptions of the state of peripheral refraction in myopia [11]. In one of the last publications, which resulted in 24 months a clinical study of the dynamics of peripheral refraction in 1531 myopic children under the age of 13 revealed that a large nasal-temporal asymmetry in 30 degrees peripheral refraction at baseline was associated with lower levels of myopia progression in the future [12]. According to the authors, these data can help in predicting and controlling the progression of myopia. In earlier studies, it was noted that in the process of myopia progression, according to off-axis refraction and off-axis biometrics, refraction of the nasal half of the eye increases more than the temporal one [13,14]. In more myopic eyes, in cases of anisomyopia, a stronger off - axis refraction in the nasal half of the eye relative to the temporal one was also revealed [15]. The author believes that in the development of potential treatments to fight against myopia, it is important to understand the origin of this shift. In model experiments on primates in inducing myopia by means of two zone contact lenses forming a peripheral hyperopic defocus, the development of myopia with nasal-temporal asymmetry of refraction and a larger increasing in its temporal half of the eye was noted [16]. The author links the increasing of nasal-temporal asymmetry of peripheral refraction with growth and considers that the resulting asymmetry is a compensatory manifestation of axial elongation.

The off-axis refraction study in emmetropes revealed nasal-temporal asymmetry with stronger refraction in the temporal half [17], which is also more typical for eyes with stable myopia, in contrast to the eyes at the beginning of progression [18]. According to other authors, detection of more myopic refraction in the nasal half, unlike temporal, can be a predictor of myopia in not yet myopic children [19].

Thus, the design features of the Perifocal lens, which provides an earlier start and stronger optical effect on the nasal half of the retina relative to the temporal, are justified. In 2014, a retrospective analysis of refractometric data of 46 children aged 7 - 12 years with myopia from -1.0D to 3.75D was carried out in the ArtOptica center, which shows that wearing Perifocal spectacles for 12 months decreased axial refraction or no progression of myopia. The analysis of the refractometric data before and after wearing Perifocal was carried out by the Fourier converting of the spherical-cylindric component into interrelated vectors in order to reduce the measurement error caused by oblique incidence astigmatism, taking into account the research data indicating that the retina determines the defocus sign along the sagittal focal plane [20]. Available literature data also indicate that changes in the values of sagittal focus correlate with changes in off-axis biometrics at this point [13].

According to the data obtained in table 1, we noted that in cases of axial refraction reduction or stopping the progression of myopia, there is an increase in peripheral refraction in the temporal half of the eye with its weakening in the nasal part. The results of this study may indicate that Perifocal spectacles creates conditions for changing the ratio of peripheral refractive power between the nasal and temporal halves of the eye, which has a deterrent effect on the progression of myopia.

**Perifocal spectacles increases the accommodation ability of the eye (relative accommodation reserves, absolute accommodation volume):** Reduced accommodation functions of the eye continue to be among the likely drivers of myopia. There is no common understanding of the causes of accommodation disorders in myopia, the primary factor or accompanying process. The results of studies of geneticists published recently identified an intriguing dilemma-an increase in the threshold of retinal sensitivity to the degree of the spot blurring is the main reason for reducing the rate of adaptive response of accommodation [21] or the morpho-functional state of the ciliary muscle is the primary cause of accommodation disorders in myopia [22]. In turn, many years in wide clinical practice the optical-reflex

| | OS | | | OD | | |
|---|---|---|---|---|---|---|
| | RF′s T30 | MC(Sph) | RF′s N30 | RF′s N30 | MC(Sph) | RF′s T30 |
| **Traditional monofocal spectacles** | | | | | | |
| n 30 | 0,2547 | - 2,708 | - 0,608 | -0,1713 | - 2,4267 | 0,5953 |
| n 30 | - 0,336 | - 3,2867 | - 1,002 | - 0,814 | - 3,2413 | - 0,3193 |
| | - 0,5907 | -0,5787 | - 0,394 | - 0,6427 | -0,8147 | -0,9147 |
| Test Wilcoxon | 0,093 | 0,001 | 0,018 | 0,032 | 0,001 | 0,058 |
| **Perifocal spectacles (cases of fast progression stop)** | | | | | | |
| n 46 | 0,3577 | - 2,8555 | - 0,36 | 0,2712 | - 2,7087 | 0,5562 |
| n 46 | - 0, 0611 | -2,9688 | 0,0377 | 0,3612 | - 2,825 | 0,4437 |
| | -0,42 | -0,12 | 0,4 | 0,09 | -0,12 | -0,11 |
| Test Wilcoxon | 0,026 | 0,02 | 0,013 | 0,049 | 0,032 | 0,057 |

***Table 1:*** *Changing the off-axis sagittal focus (RF's) at 30 deg. horizontally after 12 months in groups with monofocal correction and correction with Perifocal lens.*

trainings normalizing and improving an accommodation condition are used [23-26]. At the heart of these methodologies are different ways of micro blurring the image with the objective response of accommodation. The optical design of the Perifocal lens creates the conditions for accommodation training. Progression of refraction in one and opposite directions horizontally relative to optical center of the Perifocal lens provides conditions when arbitrary and non-arbitrary versional eye movements occur in horizontal contact with the optic axis in the field of hypocorrection that is the stimulus for the accommodative response according to the type of relaxation of the ciliary muscle. Thus, the alternation of vision through a stronger and weaker correction, creates the conditions for the exercise of accommodation.

**Perifocal spectacles helps to eliminate the stimuli to accommodation from the extra-foveal retina during near work:** According to the literature [27,28], the contour of the retina in myopic eyes in accommodation during near work is not altered or even strive to be steeper, it respectively, maintains or increases the relative peripheral hyperopia. In turn, in the emmetropic eye during accommodation while doing near work, on the contrary, the retinal contour changes markedly due to increased off-axis refraction [28-30]. Thus, the preservation of relative peripheral hyperopia in the myopic eye in the horizontal meridian at near work is an incentive to accommodation, creating conditions for excessive tension. According to the literature, the stimulus to accommodation response from the retinal periphery in the region up to 30 degrees from fovea may be 1 - 2D [31]. Perifocal lens corrects peripheral hyperopic defocus and help to eliminate not physiological stimulus to the response of accommodation from extra-foveal image focus.

**Perifocal spectacles induces positive spherical aberrations in the eye:** We know from literature [32,33] that physiologically the sign of the spherical aberrations of the eye in children varies with age. Thus, during the distance fixation in children up to 6 years, negative spherical aberrations prevail. After 6 - 7 years and throughout life, only positive spherical aberration prevails in the eye, when fixing into the distance. Studies have shown that positive spherical aberrations have a physiological effect on the eye, inhibiting eye growth and minimizing the tendency to myopia [34,35]. The Perifocal lens, due to the progression of horizontal refraction, provides conditions for stronger refraction of the rays going into the eye in the area of the pupil edge, which creates positive spherical aberrations in the eye [36]. In turn, studies have shown that the correction of myopia with a monofocal lens creates negative spherical aberrations in the eye that can stimulate the axial growth of the eye.

Perifocal spectacles helps to maintain high binocular visual acuity, reduce or eliminate heterophoria. Moving the visual axes of the eyes along the horizontal of the lenses Perifocal with asymmetric addition and with its asymmetric beginning creates, depending on the angle

of deviation of the visual axes, monocular micro blurring of the visual image or, with a small difference in the degree of severity for each eye, binocular micro blurring of visual images, which causes a soft dissociation of the binocular visual image. Mild dissociation of binocular visual image, according to the canons of orthoptic and diploptic [37], is an incentive to enhance the correspondence between the retinas and the development of bifoveal fusion, which helps to preserve the binocular visual acuity and reducing or eliminating heterophoria.

Clinical study of the perifocal spectacle lenses effect on axial and peripheral refraction in patients with myopia, conducted in 2013 - 2014, Helmholtz eye research institute of the Ministry of health of Russia, identified and confirmed the multifactorial effect of Perifocal spectacles in progressive myopia contributing to the stabilization of refraction, or a significant slowdown in its progression.

Since 2013, various studies conducted by different institutions [36,38-41] the high efficiency of Perifocal spectacles in the impact on the progression of myopia, which according to the authors is in the range of 49 - 60%. The long-term results of study, conducted in Helmholtz eye research institute of the Ministry of health of Russia, for the period of 4 - 5 years of Perifocal spectacles using in children showed a decrease in the rate of myopia progression from the initial 0.8D up to 0.17D and a 60% reduction in the rate of myopia progression compared to the control group of children wearing monofocal spectacles.

Thus, the unique optical features Perifocal lens creates conditions for versatile functional impact on various eye systems in order to prevent the progression of myopia. Perifocal spectacles can be used at any age to train accommodation, relieve eye spasm, prevent the development and progression of myopia.

## Conclusion

The optical features of the Perifocal lens create the conditions for a versatile functional effect on various eye systems, which leads to stabilization or slowing down of refraction myopization in myopes. Spectacles with perifocal defocus can be used at any age to prevent the development and progression of myopia, to overcome the usual excess tension of accommodation, to improve accommodation functions and binocular interaction.

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